THE BULLETIN IN BRIEF.

M. Esnault-Pelterie to speak under auspices of the Society
on January 28.

Reports on "Fuels" and Ballistics" received by the Society;
abstracts of papers by Dr. William Lemkin and Fletcher Pratt.

Dr. Goddard prepares for exploration of Stratosphere.

New York physicist has two-step rocket ready for altitude
flight in Italy.

San Francisco member to bring out translations of works of
German rocket experts.

Study of meteorites furnishes no evidence of life away
from Earth, geologist says.

Opel foresees terrestrial rocket transportation in two decades.

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M. PELTERIE HERE.

M. Robert Esnault Pelterie, author of "L'Astronautique" and co-doner of the
Rep-Hirsch prize, will speak at the first large public meeting sponsored by the
Society on January 28 at the American Museum of Natural History, 77th Street and
Central Park West, New York. M. Pelterie, who is a member of the Society, ar-
rived in New York on January 15 and was met by officers of the Society. M.
Pelterie is a pioneer and foremost authority in the science of astronautics, his
volume on the subject being a mamoth and exhaustive study of the problems of
interplanetary travel, replete with exact mathematical calculations. In addition
to his own contributions to the new science he has, with Andre Hirsch, provided
a stimulus to scientific work by others through the 10,000 franc prize given
annually for the most important experimental or theoretical work on the subject
of astronautics. The Society and the New York public are fortunate in the op-
portunity of hearing M. Pelterie. The hall in which the meeting is to be held
seats about 1,000 persons. There is no charge for admission.

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HAS TWO-STEP ROCKET READY.

This month will witness in some respects the most ambitious attempt at an
altitude rocket flight yet made, according to a dispatch from Vienna to the
New York Times. Dr. Darwin Lyons, New York physicist, expects to fire from Mount
Redorta, Italy, a two-step rocket powered by liquid oxygen and benzol, stabilized
by a gyroscope in the tip and carrying instruments, to a possible height of 70
miles. In addition to the liquid fuel the first or lower section is said to
contain an explosive similar to T.N.T. The rocket is ten feet long, constructed
largely of a special beryllium alloy, and weighs with instruments but without
fuel, 132 pounds. Dr Lyons, who has experimented with rockets since the war
and who was injured last year by the explosion of one, believes that the ultimate
goal of rocket development - interplanetary flights with passengers - will be
achieved in the next generation.

ROCKET FUELS.

By William Lemkin

(Abstract of report delivered to the American Interplanetary Society, December 5, 1930)

The problems that confront the small group of scientists now actively engaged in research on the subject of the rocket as a possible means of interplanetary travel, are numerous and admittedly difficult. It is generally conceded that, among the multitude of questions that await solution, not one is as critical as that of a suitable fuel or propellant for the rocket. It might be well, by way of introduction, to take up very briefly the elementary chemical principles involved in the development and use of a rocket fuel. Until we discover the secret of atomic energy, or radio-activity, we must content ourselves with those standard substances, known as combustibles or fuels, which enter into a chemical union with oxygen, resulting in the evolution of heat and other forms of energy. In a rocket fuel it is essential that this chemical reaction known as combustion should result in the production of huge volumes of hot expanding gases, for it is these gases, operating on the recoil principle, that propel the rocket in space. In the burning of ordinary fuels the oxygen is derived from the surrounding air. In an explosive the chemical action is made independent of the atmosphere by including in the mixture one ingredient that supplies the oxygen. In addition the combustion takes place with such extreme rapidity that it appears almost instantaneous. Both the heat and the pressure derived from any given explosive are measures of the power to be obtained from the substance. The temperature of the reaction may run up to several thousand degrees, and the amount of heat per unit weight of explosive (measured by a bomb calorimeter) is one of the most important factors governing the power of an explosive. As for the pressures developed in a closed space by the detonation of an explosive, they are enormous. Actual tests show that in rifled fire-arms, the chamber pressures range from ten to twenty tons per square inch.

In the common type of pyrotechnic rocket, both early and modern, and even in the life-saving rocket of today, the propellant used is gunpowder. This explosive consists, as we know, of carbon, sulphur and potassium nitrate. The latter, being a strong oxidizing agent, will effect the rapid combustion of the two other ingredients, resulting in the evolution of large quantities of carbon dioxide and sulphur dioxide, as well as various solid products. Of considerably more power and adaptability than gunpowder are the various synthetic organic compounds that go under the name of high explosives. Such are nitrocellulose or guncotton, nitroglycerine, nitrostarch, various smokeless and blasting powders, dynamite, T.N.T. and a host of others. In all cases the oxygen for the combustion, instead of being mechanically mixed with the other ingredients in the form of a nitrate salt or other oxidizing agent, as in gunpowder, is chemically united with the fuel molecule into a complex organic structure. The chemical configuration of the explosive molecule is more or less unstable and under the proper stimulus it undergoes a complete disintegration, resulting in the evolution of enormous volumes of gases.
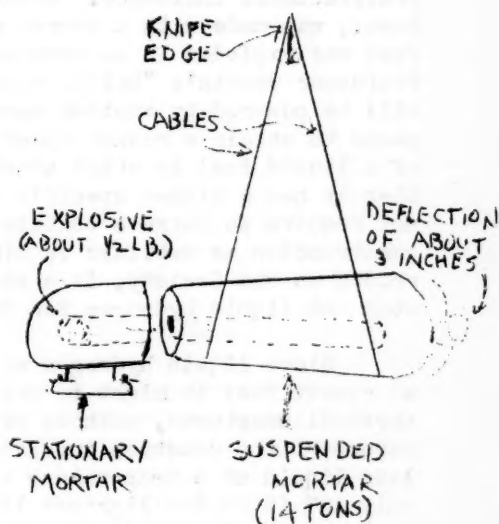
As already explained in a previous report to the Society, a vital factor in the operation of the rocket is the expulsion speed of the fuel, or more correctly, of the gases resulting from the combustion of the fuel. In the combustion chamber of the rocket, the fuel is made to combine with oxygen with explosive violence. The chemical energy stored up in the fuel is converted into heat and, in accordance with the rise in temperature involved, into pressure of the combustion gases enclosed in the chamber. Under this pressure the gases leave through the exhaust nozzle and attain a velocity that is known as the "expulsion speed."

Being forced out at such high velocity, they exercise a back-pressure on the rocket and urge it forward. The work of propulsion is therefore obtained from the energy that is chemically contained in the fuel by way of heat, pressure and recoil. It is evident that, other things being equal, the greater the expulsion speed of the ejected gases, the greater the velocity of the rocket. The search for a suitable rocket fuel therefore concerns itself largely with the discovery of a substance which will give the highest possible expulsion speed.

The accompanying diagram shows the "Ballistic pendulum" used by the American Bureau of Mines for comparing the strength of explosives, and explains how it is employed. The expulsion speeds of the ejected gases are calculated from the observed deflection of the suspended mortar and the weight of explosive used.

From purely theoretical considerations it has been determined that a rocket in flight is most efficient when it is traveling at or near the expulsion speed of the ejected gases. Based on an ideal point of view all gaseous masses once expelled from the rocket should possess no energy of their own - that is, they should have given up their entire quota of energy to the vehicle. It thus becomes manifest that, for highest efficiency, a rocket fuel must give the greatest possible expulsion speed, and that the velocity of the vehicle must, perforce, be enormous. But such velocities of both expelled gases and rocket, running into miles per second, are fundamentally essential for space travel.

FIGURE 1.
BALLISTIC PENDULUM

KNIFE EDGE
CABLES
EXPLOSIVE (ABOUT ½ LB.)
DEFLECTION OF ABOUT 3 INCHES
STATIONARY MORTAR
SUSPENDED MORTAR (14 TONS)

NOTE: CHARGE IS SET OFF BY ELECTRICITY, AND THE SWING OF THE PENDULUM IS MEASURED.

The specifications for an ideal rocket fuel are: 1. It must have the highest possible expulsion speed; 2. It must have the highest possible specific gravity, so that the smallest containers are necessary; 3. The combustion must be carried out safely, with the production of a steady motive power; 4. It must operate in such a manner as to allow the smallest possible masses being discharged in uninterrupted succession, and, 5. It must be capable of efficient handling, involving the least possible trouble.

Goddard's first experiments, using ordinary black powder, such as is employed in the life-saving rocket, gave an expulsion speed of 1000 feet per second, and an efficiency of two percent. (Goddard defines "efficiency" in connection with a rocket fuel, as the ratio of the kinetic energy of the expelled gases, calculated from their expulsion speed, to the heat energy of the fuel, derived from calorimeter measurements.) He next turned to smokeless powder and with this more powerful explosive Goddard obtained an efficiency of 64 per cent and an expulsion of 8000 feet per second. All powdered fuel experiments, however, soon led to the same conclusion. They are difficult to control. Moreover, the energies contained in them, although great, are insufficient to propel vehicle into space. Goddard's calculations showed that to lift one pound of pay load beyond the Earth's gravitational influence would require 1000 pounds of black powder or 438 pounds of the best smokeless powder. The problem is therefore beyond all reason because it would obviously be impossible to find even a light enough

container for the 438 pounds of fuel, not to mention the ship, equipment and passengers.

Goddard was the first to turn to liquid fuels as the only practicable source of rocket power. Investigators abroad have followed suit, and for the past decade research has been going on apace along the lines of liquid fuels and their utilization to propel a rocket vehicle. The best known of the rocket fuels and the one most likely to solve the problem of interplanetary travel is a mixture of liquid hydrogen and liquid oxygen. Goddard's calculations show that only 43.5 pounds of this mixture would be necessary to raise one pound of pay load beyond the earth's gravitational influence. Goddard's famous shot of July 17, 1929, at Worcester, Mass., was made with a secret fuel mixture of liquid oxygen and hydrogen. The fuel was exploded in an extremely rapid series of blasts, instead of continuously. Professor Oberth's "Baltic rocket," scheduled to be tried some time this winter, will be powered by another secret mixture of liquid oxygen and hydrogen. He expects to attain a rocket speed of 12,000 feet per second. Oberth's second choice of a liquid fuel is ethyl alcohol and liquid oxygen. One advantage of alcohol is that it has a higher specific gravity than liquid hydrogen, and therefore does not require so large a container. Oberth's theoretical rocket, whose design and construction he outlines in minute detail and which was described in an earlier report to the Society, is a step rocket employing alcohol as fuel for the first step and liquid hydrogen for the second.

Since liquid hydrogen and liquid oxygen bid fair to play an important role as rocket fuel it might be well to recall briefly some data regarding their physical constants, methods of preparation, transportation and handling, and the nature of the reaction involved in their use. Hydrogen is converted into a colorless liquid at a temperature of -252 degrees C. Having a specific gravity of only .07 it is the lightest liquid known to chemists. Oxygen liquefies at a temperature of -181 degrees C. It is a mobile transparent, faintly blue liquid, having a specific gravity of 1.2. In the liquefaction of gases two problems are involved; cooling the gas to the necessary low temperature and insulating the resulting liquid against heat from the outside. (Methods of meeting these problems in using the liquefied gases as rocket fuel are set forth in Mr. Lemkin's paper but cannot be included here for lack of space.)

It is Noordung's belief that a better fuel than either alcohol or liquid hydrogen may well be the pure hydrocarbons. He states that in comparing fuels as to energy content the number of calories per unit volume of fuel is of much more significance in rocket construction and rocket efficiency, than the number of calories per unit weight. In general, he says, the compounds rich in carbon prove superior to those rich in hydrogen, though the heating value per unit weight is higher for the latter. Accordingly he suggests benzol (benzene) as a suitable fuel because of its high energy content per liter. Pure carbon itself would be the ideal substance, but since this does not occur in liquid form he offers the possibility of a mechanical mixture of finely divided carbon in its purest state, such as lampblack. This combination would form an especially efficient rocket fuel, perhaps the best possible as far as our present knowledge of substances extends.

Future fuel research in the direction of atomic energy might prove to be fruitful. Surely, the theoretical aspects of the case, as outlined by Pelterie, indicate that there is a worthwhile field for fuel investigation. Perhaps also it might be possible in interplanetary space to utilize the energy of the sunlight directly, with a considerably higher degree of efficiency than can ever be achieved here at the bottom of the atmospheric ocean that covers our earth.

Possibly a simple chemical substance exists, or may be synthesized with comparative ease - a substance which could be made to absorb a small fraction of the limitless energy that abounds in interstellar space, and give it up again in the shape of kinetic energy to drive a rocket. Goddard, himself, has suggested that, for space travel, it may some day be possible to collect sunlight or starlight, and convert this energy, in some manner now unknown, into the necessary force for propulsion. These are, of course, mere conjectures.

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BALLISTICS OF THE ROCKET.

By Fletcher Pratt.

(Abstract of report read at meeting of December 19, 1930)

Ballistically the problems of a rocket flight to the moon or another planet are three:

1. The problem of the resistance of the air, with which is bound up the problems of shape and of maintaining the necessary high speed,
2. The problem of stabilizing the rocket in flight, and
3. The problem of steering the rocket in flight.

Before we consider them I wish to begin with a series of definitions. Suppose we take a purely theoretical rocket of cylindrical section. It has three axes running through its center of gravity. The axis reaching from top to bottom (when the cylinder stands on end) is the vertical or longitudinal axis; that parallel to the observer the horizontal axis and that perpendicular to the observer the transverse axis. Between these two there is no practical difference. The points where the axes touch the ends and sides of the cylinder are the axis points.

Now as to the resistance problem. The resistance of the air is generally assumed to vary with the square of the velocity of an object passing through it. This is only roughly true even at ordinary velocities. At very low velocities it is definitely untrue, and as to high velocities we lack evidence. In artillery practice this formula was long used to determine atmospheric resistance; or rather, since artillerymen are interested in how much the air slows up their shells, atmospheric retardation:

$$R \text{ equals} \frac{(vG)v \cdot (H)y}{C}$$

where "v" is the velocity, "G" is a factor representing the tabulated retardation of a standard shell under normal firing conditions, the "H" function of "y" is a function of the height of the trajectory, and "C" is the "ballistic coefficient." The results from this formula are subject to wide errors and would be most undependable for rocket firing at such velocities and for such distances as we are contemplating.

There is experimental evidence on air resistance for projectiles up to 16 inches in diameter and for muzzle velocities up to 3000 feet per second. But the curves plotted both from this evidence and from formula are useless at high velocities and long ranges, as they are at very low velocities. When the Germans invented the long-range gun that fired on Paris from a distance of 75 miles they used both in determining the form of their projectile and the powder charge to despatch it. Both failed and they spent a whole year of experiment on the trial and error method of determing the charge. And their muzzle velocity was only 5300 feet per second - far less than the speeds we are contemplating.

Moreever, artillery air resistance calculations and tables are all based on the idea of a projectile which is constantly losing speed, But our interplanetary rocket is a projectile with a great and growing acceleration. Therefore, I should say that the first ballistic question to be settled with regard to the rocket is the atmospheric resistance to rockets of all speeds, of all sizes and all degrees of acceleration; and it is a question that can be settled only by a long course of practical experiment, since our theoretical knowledge is so very hazy and contradictory. (Noordung estimates the amount of fuel necessary to overcome air resistance at nearly 33 percent of the total for a flight to the moon, but gives no basis for his calculation.)

The next problem is that of stabilization. I suppose I need not remind you that any projectile in flight, from a baseball to a bullet, is unstable along its vertical axis; that is, it tends to rotate in the plane of the horizontal or the transverse axis or both. There are inevitable small weight differences tending to pull the projectile out of its correct balance; the propelling force, applied at the base, exerts a powerful leverage and if the force is not applied directly at the axis point a certain proportion of it will go into the work of rotating the projectile. To overcome this, rifling was introduced. It imparts a rotary motion to the projectile which, besides its stabilizing gyroscopic effect, tends to smooth out inequalities in weight by bringing the heavier sectors into different positions at different times. Even in theory this would not grant our hypothetical rocket a high degree of stability, and in practice the rotary motion imparted by the rifling is not sufficient for its purpose.

Of course for a rocket the ballistic conditions are somewhat improved. We can place the explosion chamber, that is, the propulsive force, nearer the center of gravity. In fact, it would seem essential that the explosion chamber include the center of gravity. But we are dealing with much longer ranges and higher velocities that anything encountered by military porjectiles, which increases hugely the disturbing factor of air resistance. Unless our rocket were exquisitely balanced it would most certainly lack stability, which, in turn, would throw it far off its course, for the instant our rocket departs from absolute stability in the line of its course, the acceleration we are giving it would drive it ever farther and farther from its destination.

The stability question has engaged the attention of theorists, if not of experimenters. Oberth suggests a gyroscope connected through some electrical device (which he does not explain) with the exhaust of the rocket and arranged to alter the direction of the exhaust stream with regard to the rocket when it gets off course. Mr. Pendray proposes a rocket with a conical explosion chamber (such as commercial sky-rockets have) and a gyroscope in the very nose of the machine. The gyroscope wheel would enclose a tiny electric motor driven by a flashlight battery and set off by a trigger at the time of the rocket's release. The axis of the gyroscope would be prolonged to engage a ring which would be connected with the contact points of electromagnets operating the four fins which would stablize the rocket. I have no confidence in either arrangement. Both bear a strong resemblance to the steering mechanism of military torpedoes. Torpedoes in water are unreliable at ranges exceeding 6000 yards. Yet the advocates of this device are proposing to fire a rocket through somewhere near 175,000 yards of resisting medium at high speed with a stabilizing device that will not work beyond one-thirtieth of this distance.

In another place Oberth proposes a seismometer which will automatically alter the direction of the exhaust tube at the first indication of irregular motion, which would manifest itself in the form of vibration. He himself admits that this idea is probably not practical, and it has the disadvantage that a very slight falling off course would probably not affect it and a rapid and

pronounced falling off course would cause so violent a reaction as to throw the rocket a long way in the other direction.

In short there is not now any known method of stabilizing a rocket's flight for long distances, and the search for one, and experiments on the stability question in general, would seem to be one of the leading tasks confronting research men engaged on the subject.

I have left the question of steering until the last because it includes so much of the other problems. The question of steering rocket through the air is, of course, the question of stability. If we can find a perfectly accurate stabilizing device, then all we will have to do is shoot our rocket off on a correct course. But this is a practically unattainable ideal. I suppose you all know that a rifle, held rigidly in clamps and firing identical bullets at a target 100 yards away will not drive them through the same hole.

There remains the possibility that some compensating device could be installed to correct any error in the course after the rocket had left the atmosphere. In the case of a manned rocket this would be much simpler. Oberth, for instance, offered the idea of wheels of considerable mass inside the rocket - preferably two at right angles to each other. They would be rotated by hand and would affect the course of the rocket in the same way that a movable platform mounted on ball bearings would be affected if a man standing on it were to swing his arms back and forth. Hohmann also suggests crawling around the inside of a manned rocket to alter its trim. Both ideas seem somewhat insensitive at the velocities contemplated, and I don't think we have reached the stage where we can discuss a manned rocket.

I am informed that an American experimenter thinks a battery of photoelectric cells actuating some steering gear (perhaps a series of auxiliary explosion tubes at the perimeter of the rocket's base) would do the trick. That is, the course having been determined, the cells could be set to receive a certain amount of light from the sun at every given moment. If they received more or less light than the correct amount they would close an electric circuit and fire steering tubes until the rocket was on its correct course. Such a device would be extremely delicate, and I am not certain that it would not be thrown out of order by the types of radiation other than light which Sir James Jeans is convinced exist in outer space. But before it or any other similar steering mechanism could be installed; before even a manned rocket with the simplest of steering devices could be sent out, one more piece of ballistic calculation must be made.

The trajectory of the rocket from the point of its departure to the moon must be determined and a series of tables drawn up for rockets of different speeds and degrees of acceleration, showing the optimum time for leaving the earth and arriving at the moon as well as the best points on earth to leave from. At a rough guess I would say that there is enough mathematical work in this task alone to occupy a sizeable group of scientists for a couple of years. I suggest it as another field of research.

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DOUBTS LIFE AWAY FROM EARTH.

A study of meteorites in museums all over the world gives no evidence of life existing anywhere in the universe outside of our own planet, Dr. George F. Kunz told the Geological Society of America at its recent convention in Toronto, according to a brief report in the New York Times. That Dr. Kunz found no direct evidence of life on these solid particles from outer space is

hardly surprising in view of the fact that they are heated to white incandesence by the friction of the atmosphere, and that only small portions of the larger ones ever reach the surface of the earth in solid form. As an affirmative conculsion Dr. Kunz is reported to have expressed the opinion that conditions in whatever sphere the meteors originate are very different from those on Earth. Iron is found in large quantities in them, he pointed out, mentioning at the same time that on Earth iron rusts and disappears when exposed to the influence of oxygen and water.

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PREDICTS 3-HOUR BERLIN-NEW YORK FLIGHT.

Within two decades New York and Berlin will be linked by rocket vehicles flying at an altitude of 30 to 40 miles and making the flight in three hours, according to a prediction voiced by Dr. Fritz von Opel, German automobile manufacturer, during his recent visit here. Dr. Opel, who for a time was associated with the late Max Valier in experiments on rocket-propelled automobiles and airplanes, is now working with Professor Frederick Sanders in experiments with liquid fuels. He expects to try a flight across the English Channel in a rocket-propelled plane as the first spectacular demonstration of the practicability of his ideas.

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WORKS ON ALTITUDE ROCKETS.

The winter months may see the first of the high-altitude rockets on which Dr. Robert H. Goddard is concentrating his present work, fired from his isolated experiment field in New Mexico. While Dr. Goddard consistently refuses to make public statements of the progress of his work, dispatches to the newspapers reveal that he has apparently developed a continuously-burning liquid fuel which marks a distinct advance in the search for the ideal rocket propellant. Altitudes of 100 miles, achieved by rockets carrying instruments which will bring back safely to earth scientific data on the nature of the upper atmosphere, are believed to be within the scope of the American scientist's immediate expectations.

TO PUBLISH GERMAN TRANSLATIONS.

Dr. Alexander M. Zenzes, of San Francisco, a member of the Society, has completed translations of the works of Hermann Oberth and Max Valier. "Oberth is in my opinion perhaps the most competent scientist on the subject of cosmonautics," Dr. Zenzes writes, "whereas Valier's merit was more on the practical side. His (Valier's) book is excellently written and, although not strictly scientific, just of such a nature as to give a splendid introduction to the subject. As it now stands I have, after some exchange of opinion with Oberth and his and Valier's publisher, decided to bring out Valier's book first and then, after a short interval, Oberth's treatise."

Meetings of the New York members of the American Interplanetary Society are held on the first and third Fridays of each month at the American Museum of Natural History, 77th Street and Central Park West. Persons interested in the aims of the Society are invited to attend and to write to the secretary, C. P. Mason, 302 West 22nd Street, New York City, for information about the various classes of membership, including active, associate and special, which are open to men and women who possess the necessary qualifications.